



⑪ Publication number : **0 357 536 B1**

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## EUROPEAN PATENT SPECIFICATION

④⑤ Date of publication of patent specification :  
**21.04.93 Bulletin 93/16**

⑤① Int. Cl.<sup>5</sup> : **A46D 3/05, F16J 15/32,**  
**A46B 3/06**

②① Application number : **89630141.3**

②② Date of filing : **30.08.89**

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⑤④ **Method and apparatus for manufacturing compliant brush seals.**

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③① Priority : **30.08.88 US 238082**

④③ Date of publication of application :  
**07.03.90 Bulletin 90/10**

④⑤ Publication of the grant of the patent :  
**21.04.93 Bulletin 93/16**

⑧④ Designated Contracting States :  
**DE FR GB**

⑤⑥ References cited :  
**EP-A-01 924 76**  
**DE-A- 2 830 839**

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## Description

### FIELD OF THE INVENTION

The present invention relates to a method and an apparatus useful in assembling compliant brush seals.

### BACKGROUND

Compliant seals for preventing gas leakage between a stationary housing and a rotating shaft passing therethrough are well known. Such seals include a plurality of individual bristles consisting of metallic wire or other fiber, extending from a backing member into contact with the rotating shaft. The ends of the bristles brush lightly against the rotating shaft, hence such seals may also be termed "brush seals".

The packed bristles of the seal discourage gas flow between the stationary housing and the shaft, while the contact of the bristles with the shaft establishes a "zero clearance" between the seal and shaft further enhancing the seal effectiveness.

Such seals include inherent advantages in terms of resistance to high temperatures and the ability to accommodate radial runout of the shaft, as well as reduced component cost as compared to known labyrinth or knife edge seals used in gas turbine engines.

As has long been appreciated by those familiar with such sealing elements, it is necessary to pack the individual bristles uniformly about the circumference of an annular seal as well as to align each bristle element properly so as to achieve the desired advantages. It is easily apparent that even a slight deficiency in the arrangement of the bristles about the backing ring can give rise to a leakage path which could compromise the brush seal effectiveness.

Present methods of manufacturing brush seals preassemble a quantity of individual bristles into a quantity of small bundles which are arranged and temporarily secured at the desired alignment. The backing member is fabricated from two annular rings which are disposed on opposite sides of the assembled bristle bundles with the bristles and annular backing rings being permanently secured, thus forming the completed seal.

One such method, disclosed in US-E-30,206, provides an annular holding ring having a plurality of radial holes disposed therein. Bundles of individual bristles are drawn radially into the holes and secured by a wire loop pulled manually through the holding ring outer periphery. After drawing all the individual bristle bundles into the holding ring, first and second annular backing rings are fused to the bristles and the brush seal separated from the holding ring by cutting or otherwise machining away the excess bristle material. The remainder of the individual bristle bundles must then be removed from the holding ring and the

process repeated for the next seal.

Another prior art method, disclosed in US-A-4,274,575, preassembles individual bristle bundles into short cylindrical tubes, arranging a plurality of such tubes about an annular holding member in the desired orientation. The small tubes may be secured by adhesive or some other convenient scheme. The annular backing rings are again placed adjacent the protruding bristles and fused or otherwise permanently secured to form the brush seal.

A method of manufacturing a compliant seal and a fixture for assembling a compliant seal according to the precharacterizing portions of independent claims 1, 4 and 7 is disclosed in EP-A-0 192 476. According to this known method the bristle elements are placed on the upper surface of a lower backing ring and clamped thereto by clamping fingers. Upon laying all of the bristle elements, they are clamped by a clamping plate to the lower backing ring and the clamping fingers are removed. Thereafter, an upper backing ring is applied to the bristle elements and the so assembled seal is clamped between a lower and an upper holding ring to allow for permanently securing the bristle elements to the backing rings.

Such preassembly methods require additional steps to temporarily secure the individual bristle bundles prior to positioning and permanently securing the annular backing rings. Additionally, the use of discrete bundles of bristles can result in a nonuniformity of the bristle density in the circumferential direction. Further, and in particular with respect to the holding member having a plurality of radial passages disposed therein, repeated use of the holding member results in wearing of the passages and the possibility of the occurrence of misalignment of individual bristles.

Therefore the object of the present invention is to provide a simple and effective method and fixture, particularly well adapted for use with automatic machinery, for holding, aligning, and positioning a plurality of individual bristle elements preparatory to securing the bristle elements to a backing ring thereby forming a completed brush seal.

According to one form of the invention, to achieve this, there is provided a method of manufacturing a compliant seal having a plurality of bristle elements secured to first and second annular backing rings and adapted to extend radially into contact with a rotating shaft, comprising the steps of sandwiching a portion of the bristle elements between the first and second annular backing rings, releasably securing the bristle elements between the annular backing rings by clamping the rings between first and second holding members, permanently securing said bristle elements to said backing rings, and releasing the backing rings and bristle elements from the first and second holding members, characterized in that, prior to the step of sandwiching, the bristle elements are

placed within generally radially extending grooves evenly distributed about the circumference of an annular flat surface of an annular aligning member, said bristle elements being placed in said aligning member so that the bristle elements are aligned with the grooves and a portion of the bristle elements extends radially from the grooves, and that the step of sandwiching comprises sandwiching the bristle elements between the backing rings in the portion extending from the grooves.

According to another form of the invention, to achieve this, there is provided a method of aligning and holding a plurality of bristle elements preparatory to permanently securing the aligned bristle elements to a separate backing member, comprising the steps of clamping said bristle elements and backing member between a first holding member and a second holding member, and permanently securing a portion of each of the bristle elements to the backing member, characterized in that, prior to the step of clamping, the bristle elements are placed within generally radially extending grooves formed in a flat surface of an aligning member and oriented coincident with a desired alignment of the bristle elements, said bristle elements being placed on said aligning member so that the bristle elements are aligned with the grooves and a portion of the bristle elements projects from one end of the grooves, and that the step of permanently securing comprises securing the bristle elements to the backing member in the portion thereof extending from the grooves.

In further accordance with the invention there is provided a fixture for assembling a compliant seal, having a plurality of bristle elements, comprising a first lower holding ring, a second, upper holding ring, first and second backing rings for sandwiching the bristle elements therebetween and disposed concentrically to the holding rings, the first and second holding rings sandwiching the first and second backing rings therebetween, and means for releasably urging the first and second holding rings together, thereby releasably clamping the bristle elements between the first and second backing rings, characterized in that the first holding ring is disposed concentrically within an aligning member having a plurality of grooves disposed in an annular surface thereof, the grooves extending generally radially with respect to the aligning member and being each adapted to receive a quantity of bristle elements therein.

The brush seal is completed by removing any excess bristle material. The holding members are ready for immediate reuse in assembling subsequent brush seals.

Unlike prior art seal assembly methods and fixtures, the means and method according to the present invention is particularly well adapted for automatic execution. By positioning the grooved aligning member in conjunction with a bristle dispensing de-

vice capable of delivering preset quantities of uniformly cut bristles, the grooved aligning member may be rotationally indexed as each groove receives the proper size and number of bristles. The clamping of the aligned bristles between the holding members against the backing member(s), either comprising a single annular member or a pair of annular members sandwiching the bristles therebetween, to be removed from the aligning member and machined, welded or otherwise worked without disturbing the desired alignment. The backing rings and bristles are permanently secured by any of a variety of known methods such as welding, soldering, bonding, etc.

Both these and other features and advantages of the seal assembly method and apparatus of the present invention will be apparent to those skilled in the art upon review of the following specification and the appended claims and drawing figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a cross section of the assembly apparatus according to the present invention.

Figure 2 shows a view of the grooved aligning member as indicated in Figure 1.

Figure 3 shows a perspective detail of the grooved surface of the aligning member.

Figure 4 shows a completed brush seal disposed about a rotating shaft.

Figure 5 shows the assembly fixture according to the present invention arranged for automatic manufacture.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing figures, and in particular to Figure 1 thereof, an apparatus according to the present invention will be described in detail. Figure 1 shows a fixture arrangement 10 according to the present invention. The fixture 10 includes an annular aligning member 12 having in annular surface 14 which is adapted, as discussed hereinbelow, to receive and align a plurality of separate bristle members 16.

The fixture also includes a first removable holding member 24 disposed, in the preferred embodiment, within the annular aligning member 12. The holding member 24 supports a first backing ring 20 adjacent the portion of the bristle elements 16 extending beyond the surface 14. A second backing ring 22 is positioned opposite the first backing ring 20, sandwiching the bristle elements 16 therebetween.

A second holding member 18 is provided behind the second backing ring 22. The holding members 18, 24 are forced together by urging means, such as a threaded bolt 29, securely but releasably clamping the backing rings 20, 22 and bristle elements 16. The

sub-assembly of holding members 18, 24, bristle elements 16, and backing rings 20, 22 is removed from the aligning member 12. The bristle elements 16 remain in the desired alignment and the aligning member 12 is ready for reuse.

The clamped bristles 16 and backing rings 20, 22 are then fused or otherwise permanently secured together forming a brush seal 30 which is ultimately used for sealing between a static housing (not shown) and a rotating shaft 32 as shown in Figure 4. The step of permanently securing the bristles 16 to the backing rings 20, 22 includes, for example, welding or fusing the bristles and backing rings together and subsequently trimming excess bristle material radially outward of the fusing weld 34.

Figure 2 shows a top view of the aligning member 12 giving a more detailed view of the clamping surface 14. Grooves 26 are disposed in the surface 14, and are angularly skewed by an angle 36 with respect to the radius of the annular surface. The angle 36 varies according to the diameter, resiliency of the bristle material, speed of rotation of the shaft, etc. but is, for most applications, approximately 45°. Raised land portions 28 separate the grooves 26 and assist the alignment of the individual bristle members 16 in the equally spaced grooves 26. Figure 3 shows a view of the grooves 26 and lands 28 as indicated in Figure 2.

Figure 5 shows one method of automating the assembly procedure according to the present invention wherein a bristle element dispenser 38 delivers a preselected number of individual bristles 16 to each groove 26 in the first member 12. The member 12 is indexed rotationally 46 relative to the bristle dispenser 38 until each groove 26 has been filled with a preselected quantity of bristle elements 16. The second clamping member 18 (not shown in Figure 5) as well as the second backing ring 22 are then positioned with respect to the fixture 10 and the bristles 16 and backing members 20, 22 temporarily clamped between the holding members 24, 18 by engaging the bolt 29.

The clamped subassembly 16, 20, 22, 18, 24, 29 is then removed and the rings 20, 22 and bristles 16 permanently secured together. The holding members 18, 24 are released and immediately reused. Additional sets of holding members 18, 24 may be provided to speed up the entire process.

As will now be apparent to those skilled in the art, the method and fixture according to the present invention has several advantageous features not known or achieved in prior art methods of compliant seal manufacture. These advantages include the simplicity of the individual fixture components, with the reusable aligning member 12 being the most complicated. Also, by clamping the backing members 20, 22 and bristle elements 16 securely between the holding members 18, 24, the risk of deformation or damage to the completed seal 30 is reduced during the sub-

sequent handling and trimming operation. It will further be apparent that the individual fixture components do not experience sliding or other wear-inducing contact with the bristles, thereby lengthening the service life of the fixture.

## Claims

1. Method of manufacturing a compliant seal having a plurality of bristle elements (16) secured to first and second annular backing rings (20,22) and adapted to extend radially into contact with a rotating shaft (32), comprising the steps of:
  - sandwiching a portion of the bristle elements (16) between the first and second annular backing rings (20,22),
  - releasably securing the bristle elements (16) between the annular backing rings (20,22) by clamping the rings (20,22) between first and second holding members (18,24),
  - permanently securing said bristle elements (16) to said backing rings (20,22), and
  - releasing the backing rings (20,22) and bristle elements (16) from the first and second holding members (18,24),
  - characterized in that, prior to the step of sandwiching, the bristle elements (16) are placed within generally radially extending grooves (26) evenly distributed about the circumference of an annular flat surface (14) of an annular aligning member (12), said bristle elements (16) being placed in said aligning member (12) so that the bristle elements (16) are aligned with the grooves (26) and a portion of the bristle elements (16) extends radially from the grooves (26), and that the step of sandwiching comprises sandwiching the bristle elements (16) between the backing rings (20,22) in the portion extending from the grooves (26).
2. Method according to claim 1, characterized by further comprising the step of:
  - trimming excess bristle length following the step of permanently securing the bristle elements (16) to the backing rings (20,22).
3. Method according to claim 2, characterized by further comprising the steps of:
  - rotating the aligning member (12) relative to a bristle dispenser (38),
  - indexing said rotation relative to the number of grooves (26) in the aligning member surface (14), and
  - dispensing a predetermined number of bristle elements (16) into each groove (26) in sequence.

4. Method of aligning and holding a plurality of bristle elements preparatory to permanently securing the aligned bristle elements to a separate backing member, comprising the steps of:

clamping said bristle elements and backing member between a first holding member and a second holding member, and

permanently securing a portion of each of the bristle elements to the backing member,

characterized in that, prior to the step of clamping, the bristle elements are placed within generally radially extending grooves formed in a flat surface of an aligning member and oriented coincident with a desired alignment of the bristle elements, said bristle elements being placed on said aligning member so that the bristle elements are aligned with the grooves and a portion of the bristle elements projects from one end of the grooves, and that the step of permanently securing comprises securing the bristle elements to the backing member in the portion thereof extending from the grooves.

5. Method according to claim 4, characterized in that the aligning member, holding members and backing member are all annular and further comprising the step of:

aligning said grooves tangent to a concentric circle disposed radially inward of the holding member.

6. Method according to claim 5, characterized by comprising the steps of

rotationally indexing the aligning member relative to a bristle dispenser, and

operating said bristle dispenser to place the preselected number of bristle elements into each groove as each groove is individually indexed into position.

7. Fixture for assembling a compliant seal (30), having a plurality of bristle elements (16), comprising:

a first lower holding ring (24),

a second, upper holding ring (18),

first and second backing rings (20,22) for sandwiching the bristle elements (16) therebetween and disposed concentrically to the holding rings (18,24),

the first and second holding rings (18,24) sandwiching the first and second backing rings (20,22) therebetween, and

means (29) for releasably urging the first and second holding rings (18,24) together, thereby releasably clamping the bristle elements (16) between the first and second backing rings (20,22),

characterized in that the first holding ring

(24) is disposed concentrically within an aligning member (12) having a plurality of grooves (26) disposed in an annular surface (14) thereof, the grooves (26) extending generally radially with respect to the aligning member (12) and being each adapted to receive a quantity of bristle elements (16) therein.

## Patentansprüche

1. Verfahren zum Herstellen einer nachgiebigen Dichtung, die eine Vielzahl von Borstenelementen (16) hat, welche an einem ersten und zweiten kreisringförmigen Tragring (20, 22) befestigt und dafür vorgesehen sind, sich radial in Kontakt mit einer Welle (32) zu erstrecken, beinhaltend die Schritte:

Einlegen eines Teils der Borstenelemente (16) zwischen dem ersten und zweiten kreisringförmigen Tragring (20, 22),

lösbares Befestigen der Borstenelemente (16) zwischen den kreisringförmigen Tragringen (20, 22) durch Einspannen der Ringe (20, 22) zwischen einem ersten und zweiten Halteteil (18, 24),

dauerhaftes Befestigen der Borstenelemente (16) an den Tragringen (20, 22), und  
Lösen der Tragringe (20, 22) und der Borstenelemente (16) von dem ersten und zweiten Halteteil (18, 24),

dadurch gekennzeichnet, daß vor dem Schritt des Einlegens die Borstenelemente (16) in sich insgesamt radial erstreckenden Nuten (26) plaziert werden, welche gleichmäßig über den Umfang einer kreisringförmigen ebenen Oberfläche (14) eines kreisringförmigen Ausrichtteils (12) verteilt sind, wobei die Borstenelemente (16) in dem Ausrichtteil (12) so plaziert werden, daß die Borstenelemente (16) mit den Nuten (26) ausgerichtet sind und sich ein Teil der Borstenelemente (16) radial aus den Nuten (26) erstreckt, und daß der Schritt des Einlegens beinhaltet, die Borstenelemente (16) zwischen den Tragringen (20, 22) in dem Teil einzulegen, der sich von den Nuten (26) aus erstreckt.

2. Verfahren nach Anspruch 1, gekennzeichnet durch folgenden weiteren Schritt:

Abschneiden von überschüssiger Borstenlänge anschließend an den Schritt des dauerhaften Befestigens der Borstenelemente (16) an den Tragringen (20, 22).

3. Verfahren nach Anspruch 2, gekennzeichnet durch folgende weitere Schritte:

Drehen des Ausrichtteils (12) relativ zu einem Borstenspender (38),

Schalten der Drehung relativ zu der Anzahl der Nuten (26) in der Ausrichtteilloberfläche (14), und Abgeben einer vorbestimmten Anzahl von Borstenelementen (16) in jede Nut (26) der Reihe nach.

4. Verfahren zum Ausrichten und Festhalten einer Vielzahl von Borstenelementen in Vorbereitung auf das dauerhafte Befestigen der ausgerichteten Borstenelemente an einem separaten Tragteil, beinhaltend die Schritte:

Einspannen der Borstenelemente und des Tragteils zwischen einem ersten Halteteil und einem zweiten Halteteil, und

dauerhaftes Befestigen eines Teils jedes Borstenelements an dem Tragteil,

dadurch gekennzeichnet, daß vor dem Schritt des Einspannens die Borstenelemente in sich insgesamt radial erstreckenden Nuten plaziert werden, die in einer ebenen Oberfläche eines Ausrichtteils gebildet und koinzident mit einer gewünschten Ausrichtung der Borstenelemente orientiert sind, wobei die Borstenelemente auf dem Ausrichtteil so plaziert werden, daß die Borstenelemente mit den Nuten ausgerichtet sind und ein Teil der Borstenelemente aus einem Ende der Nuten vorsteht, und daß der Schritt des dauerhaften Befestigens beinhaltet, die Borstenelemente an dem Tragteil in dem Teil desselben zu befestigen, der sich von den Nuten aus erstreckt.

5. Verfahren nach Anspruch 4, dadurch gekennzeichnet, daß das Ausrichtteil, die Halteteile und das Tragteil alle kreisringförmig sind, und weiter beinhaltend den Schritt:

Ausrichten der Nuten tangential zu einem konzentrischen Kreis, der radial einwärts des Halteteils angeordnet ist.

6. Verfahren nach Anspruch 5, gekennzeichnet durch folgende Schritte:

Drehweitschalten des Ausrichtteils relativ zu einem Borstenspender, und

Betreiben des Borstenspenders so, daß die vorgewählte Anzahl von Borstenelementen in jede Nut plaziert wird, wenn jede Nut einzeln in Position weitergeschaltet wird.

7. Vorrichtung zum Montieren einer nachgiebigen Dichtung (30), die eine Vielzahl von Borstenelementen (16) aufweist, mit:

einem ersten, unteren Haltering (24),

einem zweiten, oberen Haltering (18),

einem ersten und zweiten Tragring (20, 22) zum Einlegen der Borstenelemente (16) zwischen denselben und in konzentrischer Anordnung zu den Halteringen (18, 24),

wobei der erste und der zweite Haltering (18, 24)

den ersten und zweiten Tragring (20, 22) zwischen sich aufnehmen, und

einer Einrichtung (29) zum lösbaren Zusammen-spannen des ersten und zweiten Halterings (18, 24), um dadurch die Borstenelemente (16) zwischen dem ersten und zweiten Tragring (20, 22) lösbar einzuspannen,

dadurch gekennzeichnet, daß der erste Haltering (24) konzentrisch innerhalb eines Ausrichtteils (12) angeordnet ist, das eine Vielzahl von Nuten (26) hat, die in einer kreisringförmigen Oberfläche (14) desselben angeordnet sind, wobei sich die Nuten (26) in bezug auf das Ausrichtteil (12) insgesamt radial erstrecken und jeweils vorgesehen sind, eine Menge an Borstenelementen (16) in sich aufzunehmen.

## Claims

1. Procédé de fabrication d'un joint d'étanchéité souple comportant une pluralité de brins élémentaires (16) fixés à des premier et second anneaux supports (20,22) et adaptés de manière à s'étendre radialement pour venir en contact avec un arbre rotatif (32), comprenant les étapes consistant à prendre en sandwich une partie des brins individuels (16) entre les premier et second anneaux supports (20,22), à fixer d'une manière amovible les brins individuels (16) entre les anneaux supports (20,22) par suite du serrage des anneaux (20,22) entre des premier et second éléments de maintien (18,24), à fixer d'une manière permanente les brins individuels (16) aux anneaux supports (20,22) et à enlever les anneaux supports (20,22) et les brins individuels des premier et second éléments de maintien (18,24), caractérisé en ce que, avant l'étape de prise en sandwich, les brins individuels (16) sont placés dans des gorges (26) s'étendant d'une manière générale dans le sens radial, réparties régulièrement autour de la circonférence d'une surface plane annulaire (14) d'un élément d'alignement annulaire (12), ces brins individuels (16) étant placés dans l'élément d'alignement (12) de telle façon que les brins individuels (16) soient alignés avec les gorges (26) et qu'une partie des brins individuels (16) s'étende radialement à partir des gorges (26), et en ce que l'étape de prise en sandwich comprend la prise en sandwich, entre les anneaux supports (20,22), des brins individuels (16) dans leurs parties s'étendant à partir des gorges (26).

2. Procédé suivant la revendication 1 caractérisé en ce qu'il comprend en outre l'étape de coupe de la longueur excédentaire des brins après l'étape de fixation d'une manière permanente des brins in-

dividuels (16) aux anneaux supports (20,22).

3. Procédé suivant la revendication 2 caractérisé en ce qu'il comprend en outre les étapes consistant à faire tourner l'élément d'alignement (12) par rapport à un distributeur de brins (38), à indexer la rotation en fonction du nombre de gorges (26) dans la surface (14) de l'élément d'alignement, et à distribuer, suivant une séquence, un nombre prédéterminé de brins individuels (16) dans chaque gorge (26). 5 10
4. Procédé d'alignement et de maintien d'une pluralité de brins individuels en vue de la fixation, d'une manière permanente, des brins individuels alignés à un élément support séparé, comprenant les étapes consistant à serrer les brins individuels et l'élément support entre un premier élément de maintien et un second élément de maintien, et à fixer d'une manière permanente une partie de chacun des brins individuels à l'élément support, caractérisé en ce qu'avant l'étape de serrage les brins individuels sont placés dans des gorges s'étendant d'une manière générale dans le sens radial, formées dans une surface plane d'un élément d'alignement et orientées suivant un alignement désiré des brins individuels, ces brins individuels étant placés, sur l'élément d'alignement, de telle façon que les brins individuels soient alignés avec les gorges et qu'une partie des brins individuels fasse saillie à partir d'une extrémité des gorges et en ce que l'étape de fixation permanente comprend la fixation des brins individuels à l'élément support dans la partie de ces brins qui s'étend à partir des gorges. 15 20 25 30 35
5. Procédé suivant la revendication 4 caractérisé en ce que l'élément d'alignement, les éléments de maintien et l'élément support sont tous annulaires et en ce qu'il comprend en outre l'étape consistant à aligner les gorges de manière qu'elles soient tangentes à un cercle concentrique disposé radialement vers l'intérieur de l'élément de maintien, dans le sens radial. 40 45
6. Procédé suivant la revendication 5 caractérisé en ce qu'il comprend les étapes consistant à indexer en rotation l'élément d'alignement par rapport à un distributeur de brins et à faire fonctionner ce distributeur de brins de manière à placer le nombre prédéterminé de brins individuels dans chaque gorge, tandis que chaque gorge est indexée individuellement en position. 50
7. Appareil d'assemblage d'un joint d'étanchéité souple (30), comportant une pluralité de brins élémentaires (16), comprenant un premier anneau de maintien inférieur (24), un second an- 55

neau de maintien supérieur (18), des premier et second anneaux supports (20,22) pour prendre en sandwich entre eux les brins individuels (16), ces anneaux étant disposés concentriquement par rapport aux anneaux de maintien (18,24), les premier et second anneaux de maintien (18,24) prenant en sandwich entre eux les premier et second anneaux supports (20,22), et un moyen (29) pour serrer l'un sur l'autre les premier et second anneaux de maintien (18,24), de manière à fixer d'une manière amovible les brins individuels (16) entre les premier et second anneaux supports (20,22), caractérisé en ce que le premier anneau de maintien (24) est disposé concentriquement dans un élément d'alignement (12) ayant une pluralité de gorges (26) formées dans une surface annulaire (14) de cet élément, les gorges (26) s'étendant d'une manière générale dans le sens radial par rapport à l'élément d'alignement (12) et chacune des gorges étant adaptée de manière à recevoir à l'intérieur une quantité de brins individuels (16).

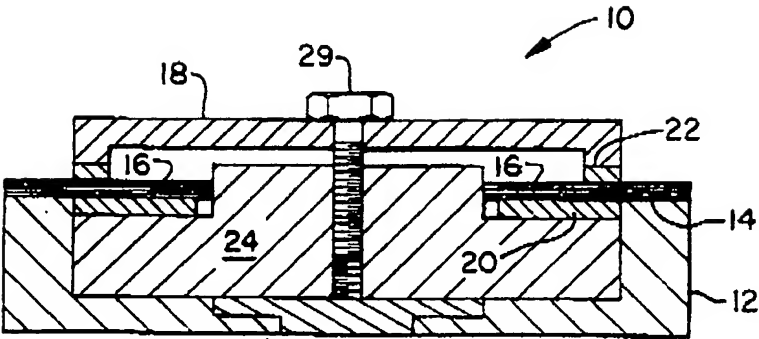


FIG. 1

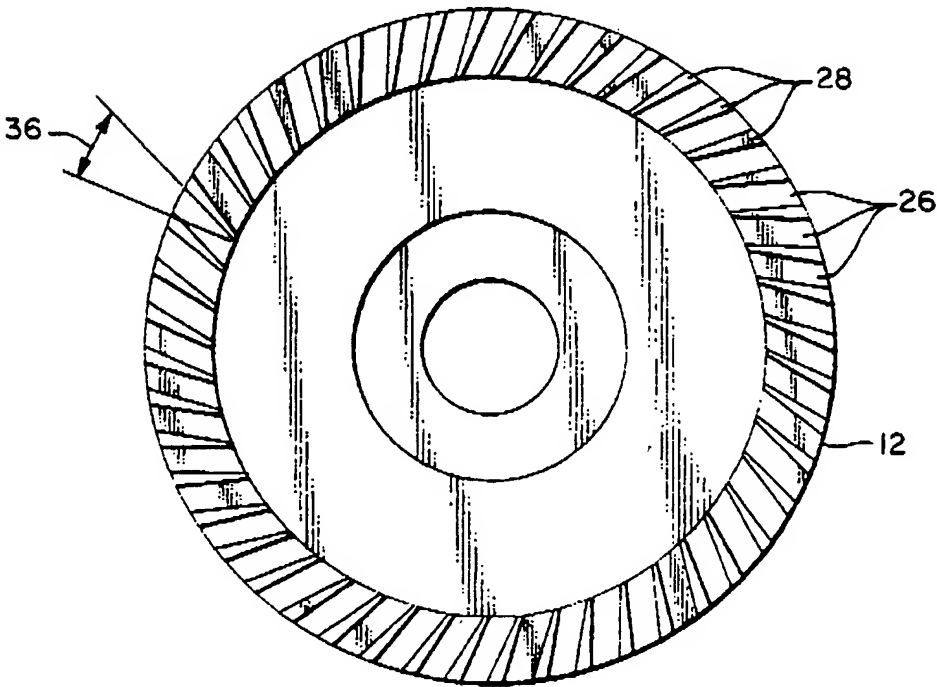


FIG. 2



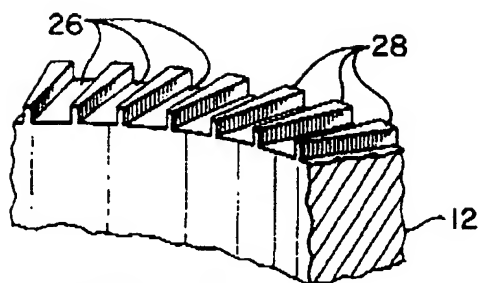


FIG. 3

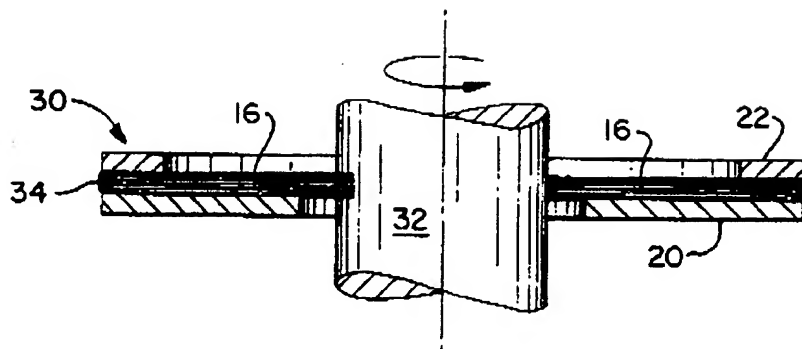


FIG. 4

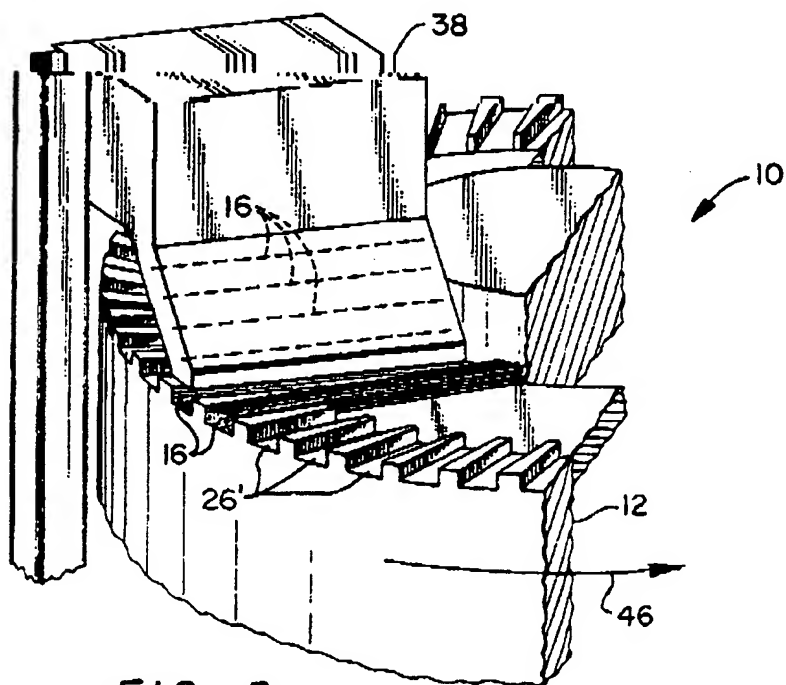


FIG. 5